THE EMISSIVITY OF STARS AT DIFFERENT TEMPERATURES.

By Paul W. Merrill.

On account of the remarkable and promising measures of the total radiation of stars, recently made by Coblentz,[1] it may be of interest to put in more accessible form a notion proposed by Nordmann and reported in the *Comptes Rendus* for March 13, 1913, and to apply it to the observed "emissivity" of stars of different colors.

Let M be the emissivity, i. e., the ratio of the heat radiated by an object to its brightness. Assume that the brightness is proportional to the intensity of the ray of wave-length 5400A. This is borne out by experiments in the laboratory, and by tests on stars. Using the Planck formula for spectral distribution of energy,—

$$E_\lambda = c_1 \lambda^{-5} (e^{\frac{c_2}{\lambda T}} - 1)^{-1}$$

and the Stefan-Boltzmann law of total radiation,—

$$E = \sigma T^4$$

we have for a black body,—

$$M = A (e^{K/T} - 1) T^4$$

where T = absolute temperature in degrees Centigrade,—

$K = 27000$

A = a constant whose value is not needed here.

If B = brightness, and E = total radiation, we have for stars 1 and 2,—

$$M_1 = \frac{E_1}{B_1};\ M_2 = \frac{E_2}{B_2}$$

L, the relative emissivity, is defined by the following equation:—

$$L = \frac{M_2}{M_1} = \frac{B_1}{B_2} \times \frac{E_2}{E_1} = \frac{(e^{K/T_2} - 1)\, T_2^4}{(e^{K/T_1} - 1)\, T_1^4}$$

$$\log \frac{B_1}{B_2} = 0.400\, (\mathrm{Mag}_2 - \mathrm{Mag}_1)$$

[1] *Publ. A. S. P.*, **26**, 169, 1914; *Lick Obsy. Bull.*, **8**, 104, 1915.

Next,—

$$\frac{M_2}{A} = (e^{K/T_2} - 1)\, T_2^4 = L\, (e^{K/T_1} - 1)\, T_1^4$$

This equation will enable T_2 to be found if L is known, and T_1 be known or assumed. Table I is to facilitate the numerical computation.

TABLE I.

$M = (e^{K/T} - 1)\, T^4 \times$ constant.

T	M	T	M
2000°	117.	7000°	0.92
2500	19.1	8000	1.16
3000	6.56	9000	1.25
3500	3.28	10000	1.39
4000	2.18	12000	1.76
4500	1.65	15000	2.56
5000	1.38	20000	4.57
6000	1.15	25000	7.60

As illustrated by Table I, the theory states that the emissivity reaches a minimum value for a temperature of 6900°, about that of the Sun. Coblentz finds, however, that the hotter stars, i. e., those of spectral classes A and B, have a lower emissivity than solar stars. This is probably due to the non-conformity of the energy curve with that of a black body. Hence we shall not attempt to determine the temperatures of stars "bluer" than the Sun by this method. Since M reaches a minimum for $T = 6900°$, a limiting value of T_2 can be found without assumption as to T_1 by putting in for it the value 6900°.

Let us take, for an example, *β Draconis* as star 1, and determine the temperature of other stars with respect to it. The following small table will be of assistance:—

TABLE II.

T depending on values of L relative to *β Draconis.*

	Assumed temperatures of *β Draconis*		
T	5000°	6000°	7000°
2000°	84.8	102.	127.
2500	13.84	16.61	20.75
3000	4.76	5.70	7.13
3500	2.38	2.85	3.56

4000	1.57	1.90	2.37
4500	1.20	1.43	1.79
5000	1.00	1.20	1.50
6000	0.84	1.00	1.25
7000	0.67	0.80	1.00

β *Draconis* Class G; $Mag_1 = 2.99$; $E_1 = 0.44$
α *Boötis* Class K; $Mag_2 = 0.24$; $E_2 = 8.58$
$L = 1.50$
β *Pegasi* Class MB; $Mag_2 = 2.61$; $E_2 = 2.82$
$L = 4.5$
19 *Piscium* Class N; $Mag_2 = 5.30$; $E_2 = 0.46$
$L = 8.8$

Assumed T of	Resulting Temperature of		
β *Draconis*	α *Boötis*	β *Pegasi*	19 *Piscium*
5000°	4100°	3050°	2700°
6000	4400	3200	2800
7000	5000	3350	2900

The numbers in the last row represent upper limits.

For the double stars measured it is remarkable to find that in every case L is larger for the faint "blue" companion than for the primary. It is interesting to note that the bright-line star γ *Cassiopeiæ* gives a low value of L compared with other stars of class B. This may indicate that the photosphere (effective radiating layer) is nearer the outside than usual, so that, while the ultra-violet radiations are still strongly absorbed, visual rays are allowed to pass more freely than in the average star of class B.

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